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MRI findings of complications related to previous uterine scars

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ABSTRACT

Although the World Health Organization suggests 10–15% as the adequate cesarean delivery rate to assure optimal prognosis for mother and children, cesarean rates have continuously increased worldwide over the last three decades, even in primiparous women. Moreover, uterine scars after myomectomies, complications of obstetrical interventions and more recently, after fetal surgery, are often observed. This review article describes the most commonly seen complications related to prior uterine scars and discusses their imaging findings, with emphasis on the increasing role of Magnetic Resonance Imaging for diagnosis.

1. Introduction

The World Health Organization (WHO) suggests a medically adequate cesarean delivery rate of 10–15% to assure optimal prognoses for both mother and children [1]. However, cesarean rates have continuously increased over the last three decades worldwide [2], even in primiparous women (Fig. 1), at the point that a cesarean is now the most common surgical procedure performed in women [3]. At the same time, uterine scars after myomectomies, complications of obstetrical interventions or even fetal surgery are often observed.

Recent statistics report a cesarean rate of 32.8% of all deliveries in USA, 38.1% in Italy [3–6] and > 50% in Brazil and Uruguay [2]. China reports a general cesarean rate of 36.2% that increases to 64.1% when referring exclusively to urban China [6] (Fig. 1). The reasons for these increasing rates are multifactorial and extremely complex [6–13]. Wide social and economic changes have led to advances in women's education and to a progressive inclusion of women in economic activities across large parts of the world, which associated to the extensive access to contraceptives have contributed to both a significant decrease of birth rates and to increasing maternal age [7]. In developed economies, the percentage of expectant mothers with advanced age, pre-existing pathologies or becoming pregnant after fertility treatments is higher than ever before. In this context, medical decisions for elective cesarean and/or maternal cesarean request for non-medical reasons are largely accepted by the society. Elective cesareans have also considerably increased in developing countries, especially in South-America [8] (Fig. 1). Finally, a wide generalization of hospital access for delivery and the development of an obstetrical medico-legal environment with fear of complications in vaginal deliveries [7–9] has also contributed to the increasing rates of cesarean in some countries.

Nonetheless, high cesarean rates also have negative consequences. They increase maternal morbidity, prolong postpartum recovery and require a longer hospitalization time compared to vaginal deliveries, causing an enormous economic impact on health costs. They also contribute to an increase of future cesareans, as the probability of having a new cesarean in a future pregnancy is > 90% and raise concerns about complications related to the uterine scar [9–12]. A cesarean scar may impair fertility and in the case of a further pregnancy, it increases the risk of ectopic pregnancy, miscarriage and stillbirth; anomalous placental location and/or implantation [10,11] and uterine rupture [12–14]. Some of these complications are at the origin of severe peripartum hemorrhages with catastrophic consequences for both mother and child. Transvaginal ultrasound exam (TVUS) remains the main imaging method performed for diagnosis, but magnetic resonance imaging (MRI) studies are useful for selected cases.

This review article describes the main complications related to prior

Abbreviations: WHO, World Health Organization; US, Ultrasound; MRI, Magnetic resonance imaging; TVUS, Transvaginal ultrasound

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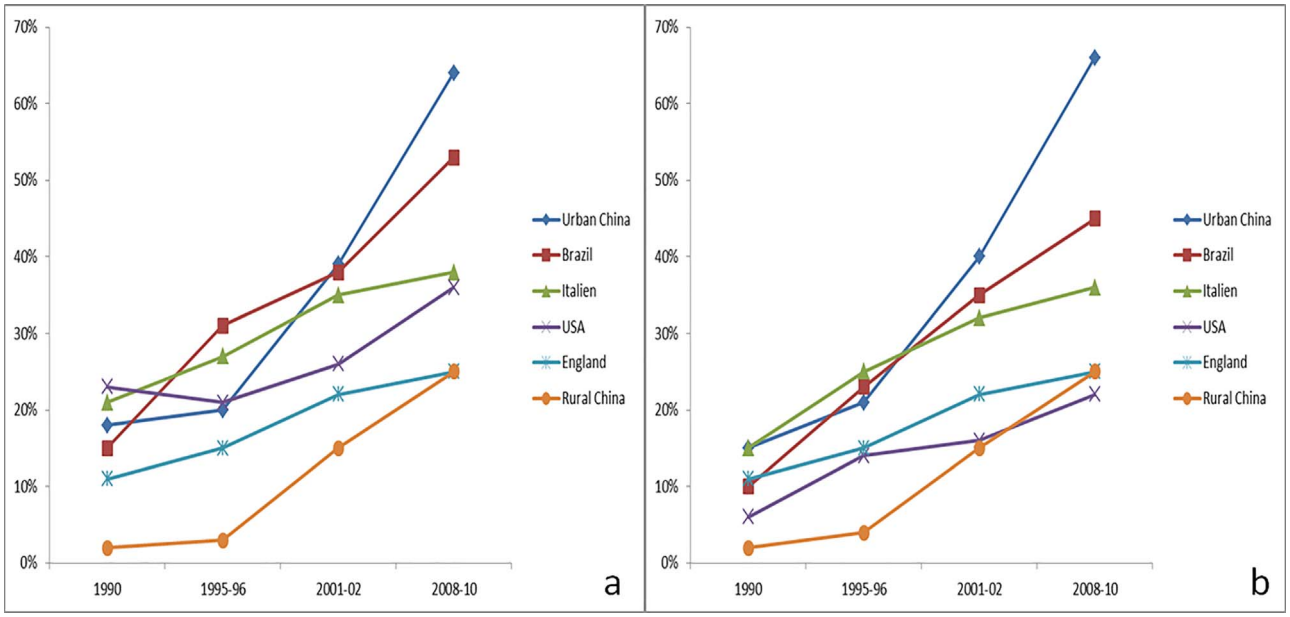

Fig. 1. Progression of cesarean delivery rates for all deliveries (a) and in primiparous women (b) in some reference countries from 1990 to 2010.

Table 1
Most frequently observed complications related to uterine scars.

Complications related to uterine scars
Uterine scar dehiscence
Uterine rupture
Abdominal and pelvic adhesions
Uterine synechiae
Cesarean scar ectopic pregnancy
Anomalous location of the placenta
Placental invasion

uterine scars (Table 1) – mainly after cesarean deliveries-, shows representative examples and describes the suggestive imaging findings, focusing mainly at MRI exams.

2. Complications related to prior uterine scars

2.1. Uterine scar dehiscence

Uterine scar dehiscence consists in a slight border separation of a prior scar causing a partial or complete disruption of the myometrium with intact serosa layer. It is mainly detected after a cesarean delivery but can also be observed in hysterotomies performed for other reasons (Fig. 2). Most women remain asymptomatic, but dysmenorrhea, dyspareunia and intermenstrual spotting are occasionally described. Most uterine dehiscence's are managed expectantly [15]. However, vaginal or laparoscopic approach should be performed in symptomatic women or in patients with a desire for a future pregnancy. Dehiscences are usually detected at transvaginal Ultrasound exams (TVUS) in patients with nonspecific abdominal symptoms, but the integrity of the serosa layer is not always well identified (Fig. 2). In selected cases, MRI exams may help differentiating the myometrium from the hypointense serosa. Sagittal images oriented perpendicularly to the scar are more accurate for diagnosis (Fig. 3).

The risk of complications in a new pregnancy depends on the extension of the dehiscence observed on TVUS performed before pregnancy. A critical cut-off uterus wall thickness of 2.5–3.5 mm at the scar

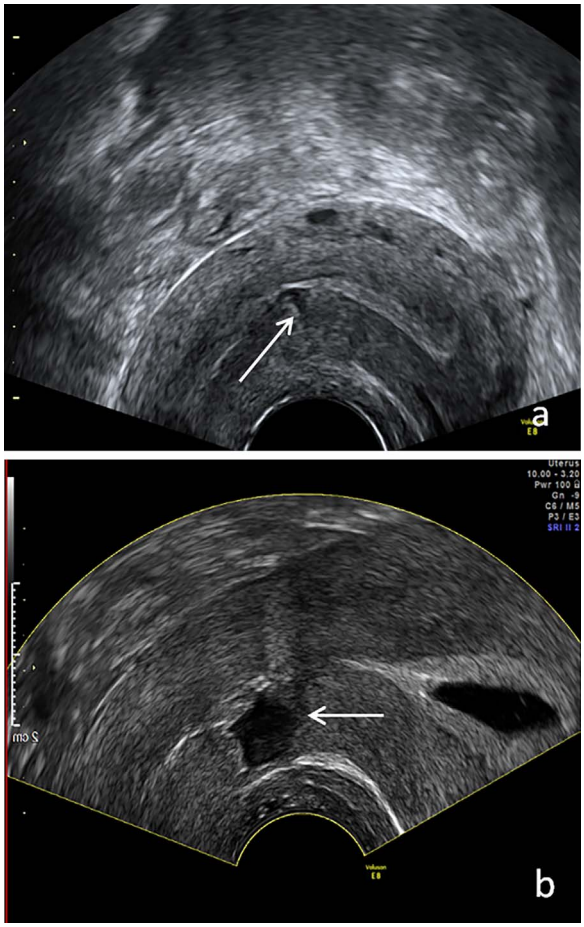

Fig. 2. Uterine scar dehiscences (Cases 1 and 2): TVUS image (a) shows a light dehiscence of the uterine wall at the level of the uterine scar in a 30 y.o. patient with a prior cesarean delivery (a, Case 1, white arrow). (b) Severe scar dehiscence (white arrow) with complete disruption of the myometrial uterine layer and preservation of the serosa in a 32 y.o. patient with 2 prior cesarean deliveries (Case 2).

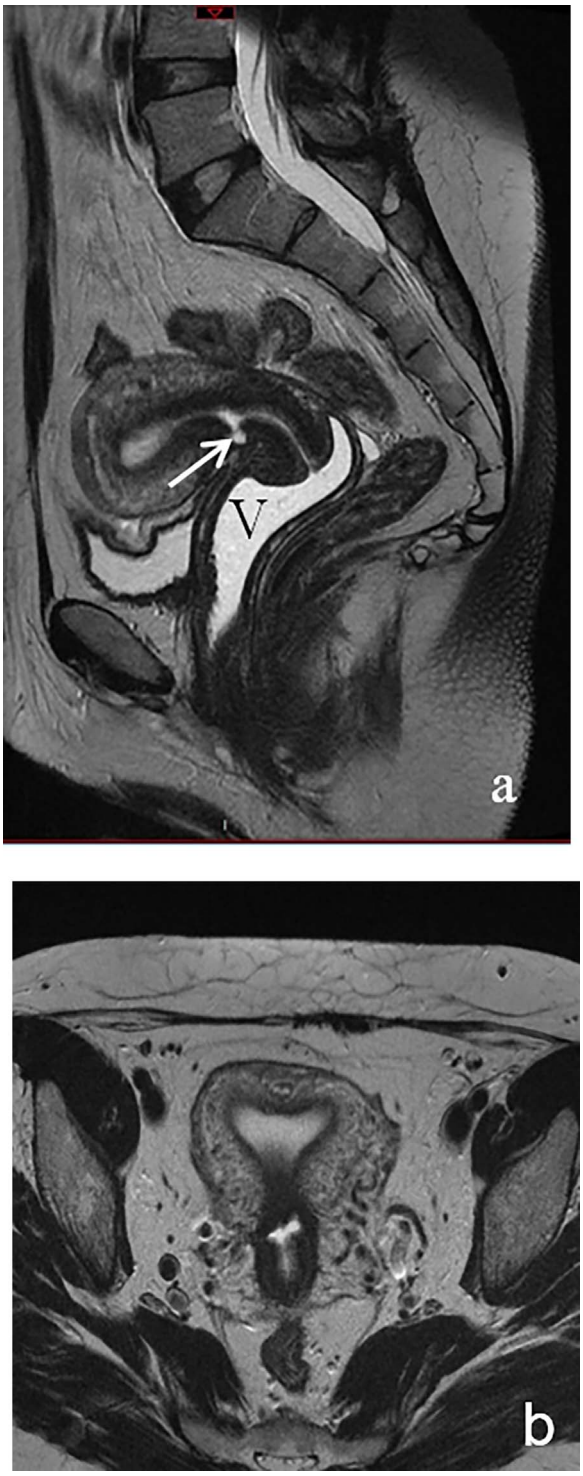

Fig. 3. Uterine scar dehiscence: 30 y.o. patient with 2 prior cesarean deliveries and non-specific abdominal pain. Sagittal (a) and axial (b) T2- W MR images show incomplete rupture of the ventral uterine wall at the level of the old cesarean scar (white arrow), involving the myometrium but with intact overlying serosa layer. V = Fluid-filled vagina.

level has been proposed as a threshold for making therapy decisions. If a future pregnancy is not excluded, vaginal delivery could be attempted if dehiscence wall thickness is > 3.5 mm whereas a wall thickness < 2.5 mm should have prior reparative surgery [15,16]. However, the detection and/or increase of a dehiscence during pregnancy often lead to a new cesarean because of the fear of uterine rupture at delivery [15].

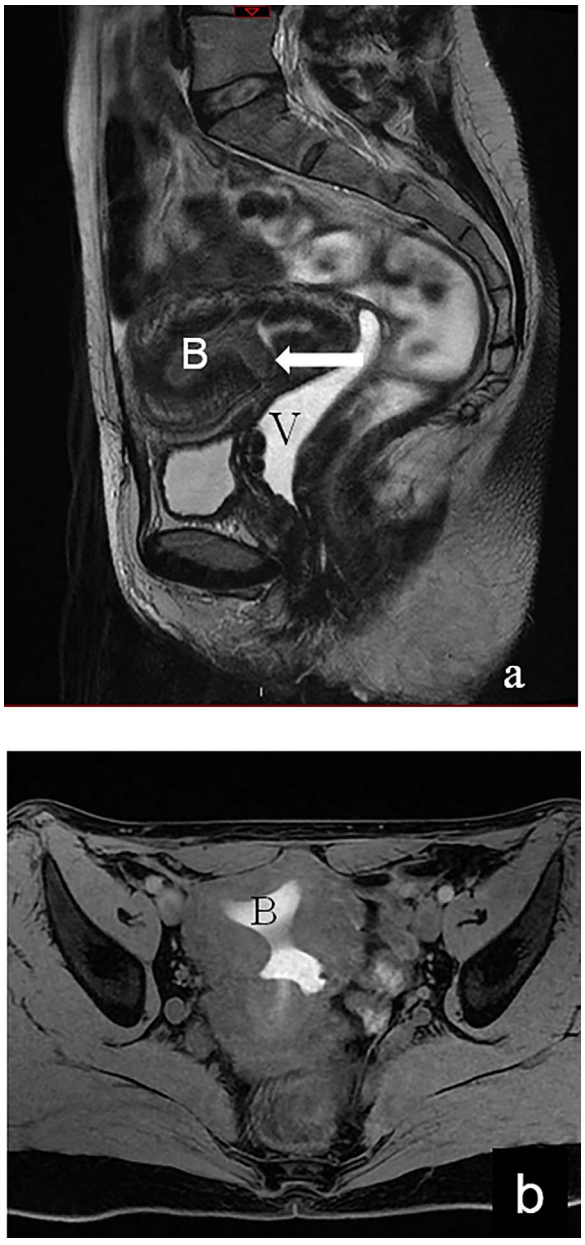

Fig. 4. Chronic uterine scar rupture with formation of a "niche".- 38 y.o. patient with 3 previous cesarean sections presenting abdominal pain and persistent vaginal spotting. Sagittal (a) T2-W MR images and axial (b) FS T1-W MR image show a semicircular defect of the ventral uterus wall at the level of the isthmus (white arrow). The cavity is filled with hematic fluid (B), also present at the cavum uteri. Menstruation normalized after surgical correction. V = Vagina.

2.2. Uterine scar rupture

It refers to a disruption of the myometrium extending through the serosa. It leads to an abnormal communication between the uterine cavity and the peritoneum that facilitates the development and spread of infections [17–19]. Rupture is incomplete when the tear is limited to a part of the scar and complete when the separation of all wall layers is detected at the whole scar extension. The main risk factor is a prior cesarean scar. Chronic ruptures are rare and often show nonspecific symptoms, including vaginal bleeding, chronic pain or infections extending into the peritoneum due to the retained secretions and menstrual blood at the tear. TVUS findings are often non-specific. MRI may confirm the serosa interruption and reveal the focal defect of myometrium, usually filled with blood rests, well identifiable at T1-W images (Fig. 4).

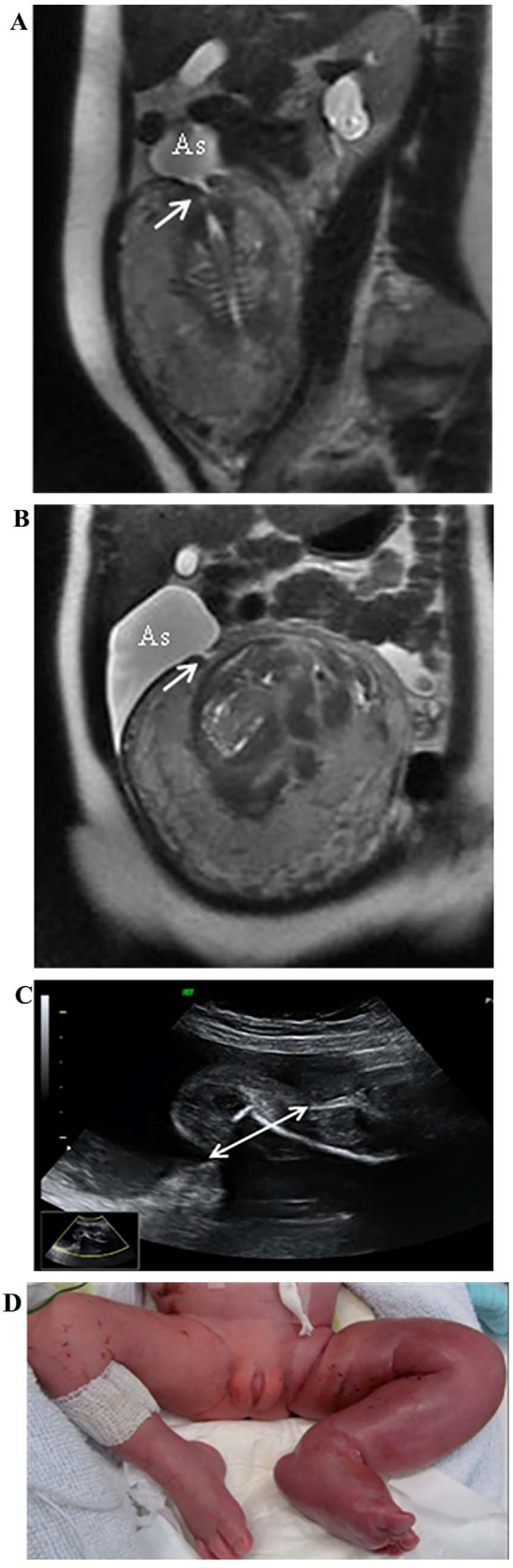

Fig. 5. Stable uterine rupture. 27 y.o. patient with antecedents of iatrogenic uterine rupture at laparotomy. Sagittal and coronal (a, b) T2-W MR images at the 29th week of pregnancy revealed a focal uterine rupture in the right uterine fundus wall, at the level of the old uterine scar, with prolapsed amniotic sac (As). The patient was treated conservatively with bed rest, i.v tocolysis and fetal lung maturation. US control at 32th pregnancy week (c) shows increased rupture of the uterine wall (double white arrow), with a leg of the fetus now extending through it. Diagnosis was confirmed at cesarean delivery. After birth, the left leg presented edema and deep furrows at the upper thigh (d).

A prior cesarean scar is the main risk factor for uterine rupture in pregnant patients and increases with the number of previous cesareans. Pregnancy intervals < 2 years also increase the risk, probably because of insufficient scar healing time [17]. The incidence is associated with the type of cesarean section performed: 0.2–1.5% for low-segment transverse sections and 4–9% for a vertical or T-shaped section [18,19]. Incomplete ruptures are usually not apparent until delivery has concluded. Abdominal US findings are often non-specific. In stable patients, MRI may help to confirm diagnosis and evaluate consequences on the fetus (Fig. 5). After delivery, patients may present with persistent vaginal hemorrhage, hemoperitoneum and a voluminous uterine wall hematoma. At contrast- enhanced computed tomography scan (CE-CT) a bladder flap hematoma > 5 cm associated to a large pelvic hematoma is suspicious in a proper clinical setting [18].

Complete uterine rupture is one of the most serious obstetric complications [17–19]. Clinical signs include acute abdominal pain, fetal heart decelerations and intrapartum fever. Severe vaginal and intraperitoneal hemorrhages may rapidly cause hypovolemic shock and require urgent delivery and hysterectomy. Imaging studies are rarely performed in this context [14].

2.3. Abdominal and pelvic adhesions

A uterine scar may be at the origin of fibrous bands or adhesions between the uterus and the peritoneum, the anterior abdominal wall and/or the adjacent organs [15,19]. The tissue inflammation following surgical disruption cause adhesions that begin to form immediately after surgery and can range from fine adhesions to a fusion of the uterus to the abdominal wall or the bladder. Their incidence and severity increases with iterative procedures [20,21]. Risk factors include intraperitoneal bleeding, infection, tissue ischemia, chemical irritation and excessive organ manipulation. Careful hemostasis and tissue manipulation, minimization of ischemia, closure of the parietal peritoneum [20,22–24] and a double-layer closure hysterotomy [25] help to prevent or reduce the formation of adhesions.

Pelvic adhesions may cause urinary disorders, bowel obstruction and chronic pain. They also reduce fertility and increase the risk of bladder injury in case of future surgical procedures [15]. Scar adhesions between the uterus and the anterior abdominal wall may cause retraction and tethering of the lower uterus. They change the orientation of the uterus with anteversion, retroflexion and elongation of the cervix and the lower uterine body, resulting in a partial displacement of the uterus out of the pelvis [17]. Abdominal US is often more efficient in these patients than TVUS, but bladder distension should be avoided as it contributes to displace the uterus from the transducer [17]. In symptomatic patients with inconclusive US, MRI may identify the adhesions (Fig. 6).

2.4. Intrauterine adhesions

Most intrauterine adhesions result from dilation and curettage – about 90% of cases- whereas cesarean section and other myomectomies are responsible for the remaining 10% [26–29]. Adhesions are almost exclusively caused by injury to the basal layer of the endometrium. The Asherman's syndrome consists of uterine adhesions causing menstrual disorders, secondary amenorrhea and impaired fertility. Although its true incidence is unclear, the American Society for reproductive Medicine (ASRM) estimates a frequency of 7% of secondary amenorrhea post dilation and curettage [30]. Pregnancy is rare in this context and if it occurs, is associated with a high risk of miscarriage, anomalous

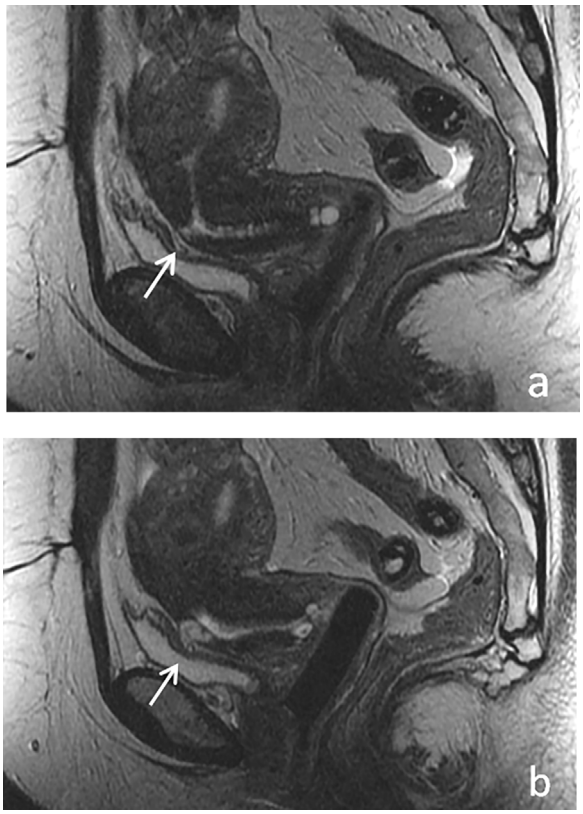

Fig. 6. Pelvic adhesions after cesarean delivery.- 39 y.o. patient with 2 prior cesarean deliveries and 2 curettages presenting with pain during miction. The sagittal (a, b) T2-W MR images show the uterine dehiscence at the level of the prior cesarean scar. Note fine adhesions (white arrow) between the uterine dehiscence and the bladder dome. Symptoms released after surgical adhesiolyisis.

placental implantation, intrauterine growth retardation and/or premature delivery. Usual treatment consists of the surgical excision of adherences at hysteroscopy [26–29].

Although hysterosalpingography is the most useful method to detect intrauterine adhesions, TVUS with or without injection of sterile saline into the uterine cavity may be used to identify the presence and severity of adhesions. Fine adhesions may be observed as thin, undulating membranes on real time scanning whereas extensive adhesions appear as dense "bridging bands" that may distort and even partially occlude the uterine cavity [31]. MRI can help in selected cases, confirming the presence of solid tissue bands between the uterine walls and providing additional information about the severity and extension of the synechiae [32]. Moreover, in pregnant patients, MRI may help to evaluate the effects of the synechiae over the gestational sac (Fig. 7).

2.5. Cesarean scar ectopic pregnancy (CSEP)

In CSEP, the embryo implants close to or within the fibrous cesarean scar. After a cesarean, the poor vascularity and the fibrosis of the uterine wall at the scar level impair a normal wall reconstruction that may produce small defects into which a trophoblast can implant. The incidence is increasing because of higher cesarean delivery rates and a better detection [33,34]. The risk augments with the number of prior cesareans. There are two types of CSEP: in the first one, the implantation of the trophoblast grows toward the uterine cavity. This type may eventually progress to a viable pregnancy but involves a significant risk of vaginal hemorrhage. In the second type, the implantation occurs deeply in the scar and progresses toward the bladder and/or the abdominal cavity, with an extremely high risk of uterine rupture [35].

Early diagnosis of CSEP is difficult because most patients are asymptomatic or have only light vaginal bleeding. However, TVUS enables diagnosis in about 84.6% of cases [34]. Suggesting findings include a gestational sac in the anterior part of the uterine isthmus, close to or into the cesarean scar with an empty uterus and cervical

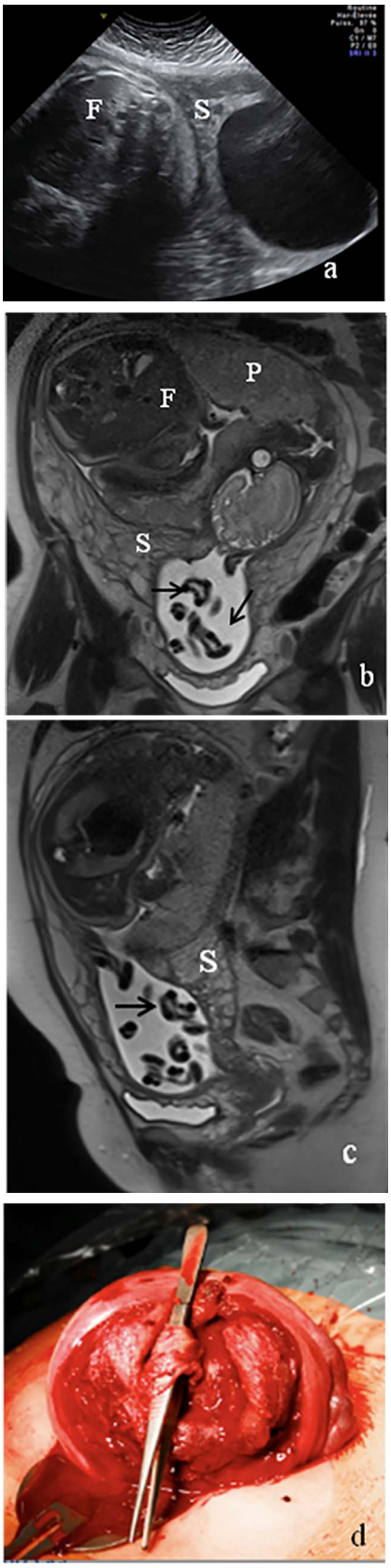

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Fig. 7. Intrauterine synechias: 28 y.o. patient with 2 previous cesarean deliveries and status post uterine rupture, presenting with vaginal bleeding at the 32th week of pregnancy. TVUS image (a) shows the transverse positioned fetus and reveals anomalous distribution of amniotic fluid with central located, unclear intrauterine tissue (S: synechia). Coronal and sagittal (b, c) T2-W MR images show a normal inserted placenta (P). A wide bridge of tissue arising from the right lateral uterine wall (S:synechia), divides the uterus in 2 compartments. The cranial one contains the transverse located fetus whereas the caudal one contains the prolapsed umbilical cord (black arrows b, c), surrounded by most of the amniotic fluid. Diagnosis was confirmed at surgery (d).

canal [35–37]. Bulging of the uterine contour at the lower uterine segment and a thin myometrial layer between the gestational sac and the bladder plane are other sonographic findings. The main differential diagnosis is a spontaneous abortion in progress. TVUS helps differentiating both entities: in CSEP, the gestational sac is ovoid and regular in shape, with normal vascularity at US Doppler whereas in spontaneous abortion the sac is distorted and/or collapsed and avascular [38]. In complicated patients with unclear or equivocal diagnosis at US, MRI may aid to confirm the exact location of the gestational sac [39].

CSEP pregnancy is a dangerous and life-threatening condition [33]. Traditional medical therapy consists of the systemic administration of Methotrexate combined or not with injection of embryocides into the gestational sac. Surgical therapy consists of the excision of the gestational sac, dilation and curettage and uterine scar repair [40]. Both therapies have a significant risk of uncontrolled hemorrhages and hysterectomy [35]. For patients who would like to preserve fertility, local administration of methotrexate combined with uterine artery embolization is a minimally invasive alternative treatment (Fig. 8). Preliminary reports show increased success rate, fewer complications and lower incidence of uterine rupture and hysterectomy than traditional methods [33,40].

2.6. Anomalous placental location

In placenta previa (PP), the placenta implants in the lower uterine segment, overlying completely the internal cervical os (Fig. 9) whereas in marginal PP, it is located at < 2 cm from the margin of the internal cervical os. The overall incidence of PP is 3–6:1000 births and has been increasing in recent years. The main risk factors are an obstetric history of prior PP or cesarean delivery. After a cesarean delivery, the risk of PP at a new pregnancy is 1.5–6 times higher than following a vaginal delivery. A cesarean section performed in a primiparous woman increases the risk of PP for subsequent deliveries in 50%–120% [41–43]. Other risk factors include advanced maternal age and birth intervals < 1 year.

Anomalous placental location is a serious obstetric complication that often causes severe peripartum hemorrhages, requiring blood transfusions and even emergency hysterectomy [40,44]. The assessment of the placenta is part of the fetal US screening exam. TVUS with color Doppler at 18–20 w. of gestation is the standard method for confirming the diagnosis. In case of incomplete or pathologic findings at US, further investigations are mandatory. Complementary MRI is recommended in placenta located near to- or in contact with a prior cesarean scar and in posterior located placenta, difficult to evaluate at US [45,46].

2.7. Placental invasion

It consists of a pathologically deep attachment of the placenta. It is classified into 3 variants based on the depth of the myometrial invasion: in placenta accreta vera the chorionic villi are attached to the myometrium but do not invade it. In placenta increta, the villi partially invade the myometrium and in placenta percreta, invasion involves the entire myometrial thickness, reaching the uterine serosa or extending beyond it (Fig. 10). The two main risk factors are a prior cesarean delivery or PP, especially if both present concomitantly. Other risks factors include smoking, uterine anomalies, advanced maternal age, multiple gestations, birth intervals < 1 or > 4 years and prior uterine surgeries [42].

The incidence of placental invasion varies from 3 to 6:1000 births and is clearly increasing due to the higher rate of cesarean deliveries in developed countries [43,47–49]. It is a severe obstetric complication, causing around 20% of all maternal perinatal deaths in the world [43,47–49]. The tight adherence of the placenta to the uterine wall interferes with a normal post-partum separation between the placenta and the uterus that is at the origin of massive hemorrhages that may turn into hypovolemic shock, requiring blood transfusions and emergency hysterectomy. Secondary complications include coagulopathies, lung embolism, iatrogenic ureteral, intestinal or bladder injuries and secondary sepsis. It is also associated with a high risk of pre-term birth and severe perinatal morbi-mortality for the child [43].

The discovery of an unexpected anomalous placentation at delivery may have catastrophic consequences. Therefore, accurate prenatal diagnosis is crucial for the optimal preparation and management of the delivery. It is extremely important to be aware of the obstetrical history of the patient, including antecedents of a prior cesarean delivery or other uterine surgical procedures. Suggesting findings at screening US include PP, placental vascular spaces with turbulent flow – lacunae –, focal loss of the normal placental-myometrial interface and/or of the retroplacental clear space and a myometrial thickness < 1 mm. In high-risk patients, TVUS with color Doppler exam is mandatory. It should evaluate the position of the placenta, the anterior uterine myometrium and the bladder wall. Suspected findings include placental blood vessels bridging the myometrium or crossing the uterine serosa, detection of multiple lacunae and interruption of the myometrial-bladder interface [50]. In placenta percreta, the bladder wall may be nodular and irregular with increased extensive vascularity. False-positive diagnoses are mostly related to an exuberant pericervical blood flow or a focal myometrial thinning in a low-lying placenta.

In patients with risk factors and limited, inconclusive or equivocal US findings, additional MRI is increasingly performed [47]. MRI provides a complete evaluation of the placenta, independently of its position and is considered superior to US for estimating the extension, topography and depth of placental invasion [50–52] (Figs. 11 and 12).

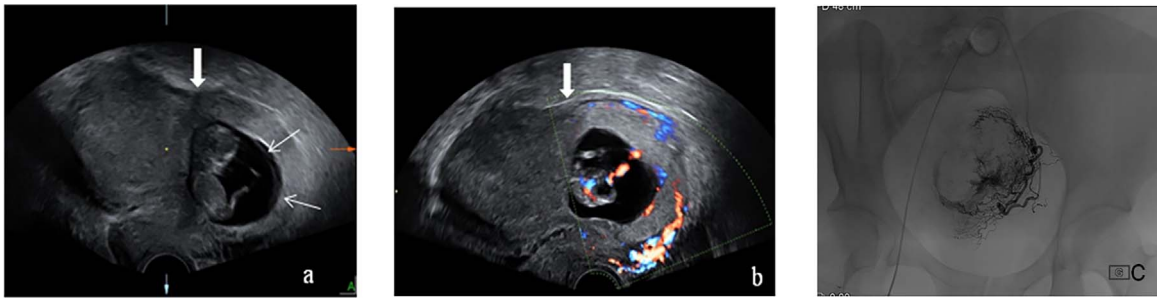

Fig. 8. Cesarean scar ectopic pregnancy.- 33-y.o. patient with a prior cesarean section presenting with vaginal bleeding at the 13th week of pregnancy. TVUS image (a) and color Doppler image (b) at the 13th week of pregnancy show the gestational sac located at the level of the old cesarean scar (block arrow). The viable embryo is well identifiable (fine arrows, a). Angiographic image before embolization (c) shows the catheter inserted in the uterine artery.

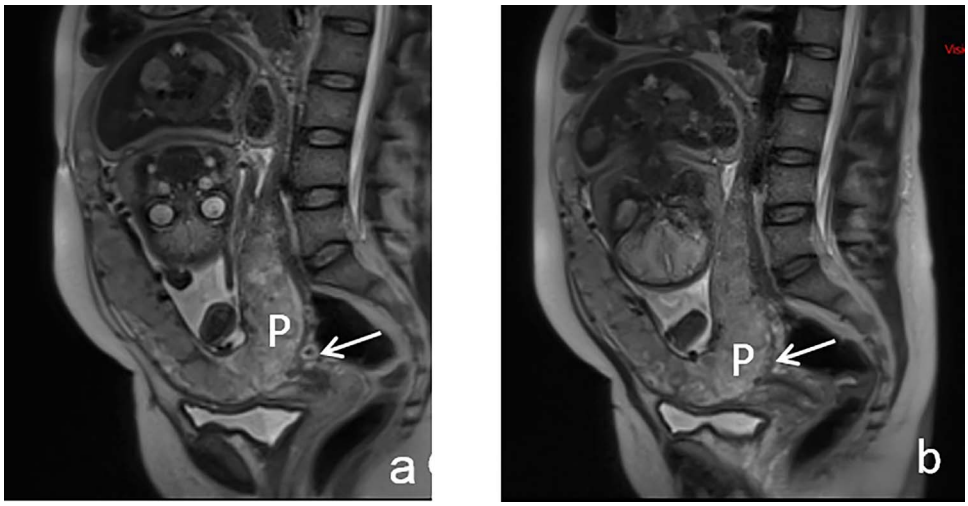

Fig. 9. Placenta previa.- 39 y.o. patient with a prior cesarean delivery presenting with light vaginal bleeding at the 24th week of pregnancy. PP was detected at US. Complementary sagittal T2- W MR images (a, b) clearly show the placenta (P), entirely covering the internal uterine os (white arrows).

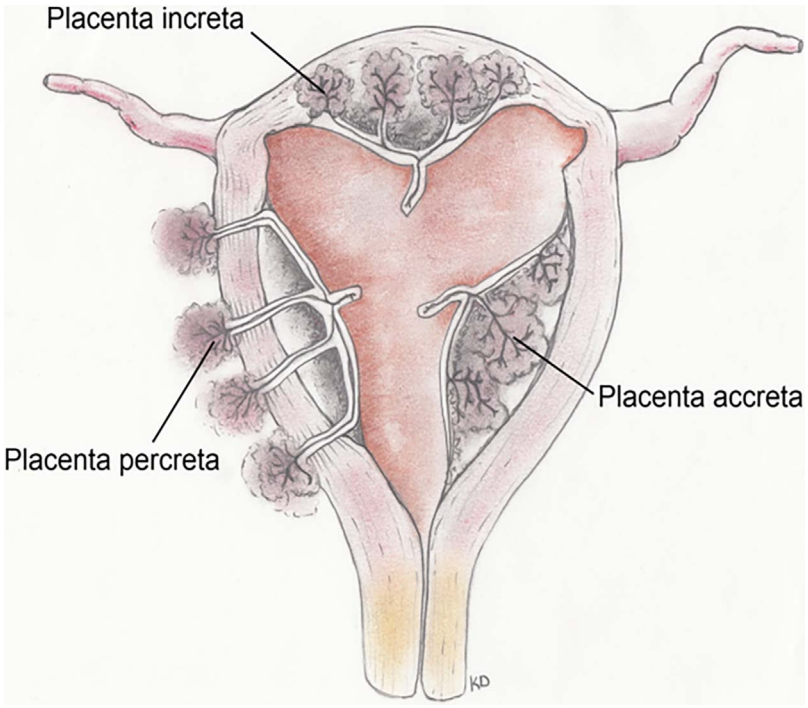

Fig. 10. Anomalous placental infiltration. In placenta accreta the chorionic villi are attached to the myometrium but do not invade it. In placenta increta, the villi partially invade the myometrium whereas in placenta percreta, invasion involves the entire myometrial thickness, reaching the uterine serosa or even extending beyond it. Printed with permission from Ref. [53].

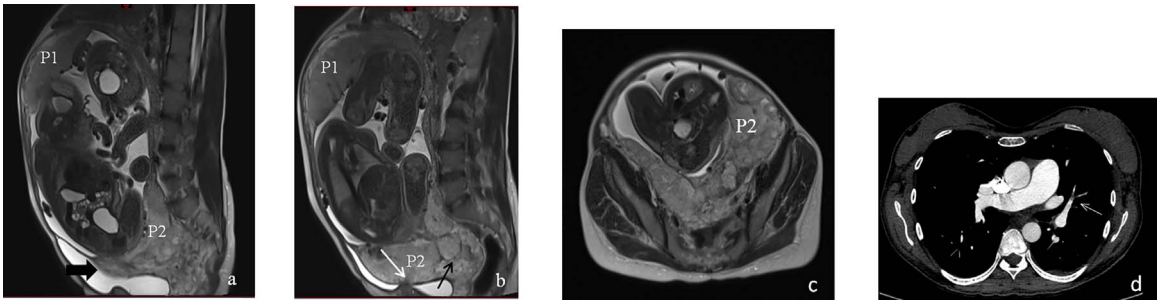

Fig. 11. PP and percreta.- 28 y.o. patient with 2 prior cesarean deliveries. The sagittal (a, b) and axial (c) T2-W MR images at the 36th w. of a twin pregnancy show the placenta previa of the second fetus (P2), entirely covering the internal uterine os (fine black arrow, b). Compared to the normal placenta of the first fetus (P1), P2 is markedly heterogeneous (b, c). Note the tethering of the bladder dome (white arrow, b) and the infiltration of the bladder dome (thick black arrow, a), confirming a placenta percreta. Despite prophylactic insertion of bilateral iliacal angioplasty catheters before delivery, severe intrapartum hemorrhage required urgent hysterectomy. The patient developed a lung embolism 4 days after delivery, showed in this axial contrast enhanced computed tomography scan image (white arrow, d).

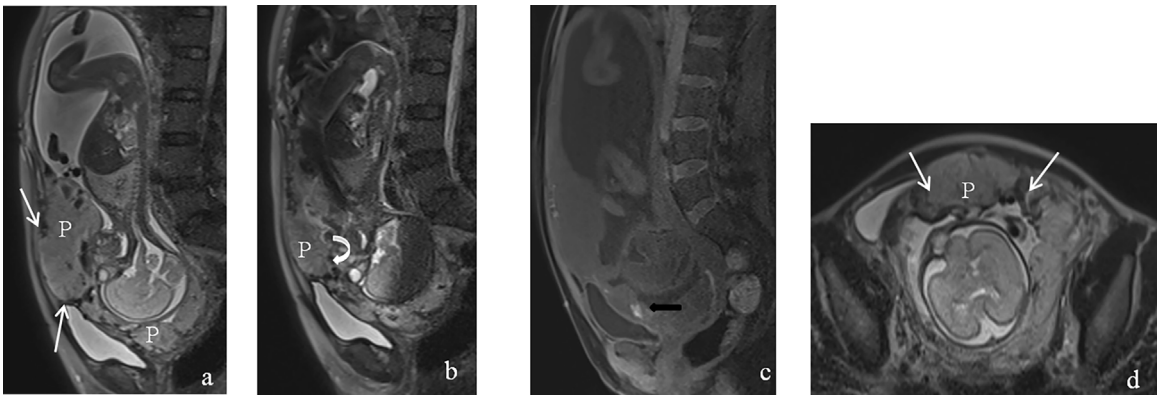

Fig. 12. PP and percreta.- 26 y.o. patient with 1 prior cesarean delivery and status post dilation and curettage. Sagittal T2-W (a, b), sagittal T1-W (c) and axial (d) T2-W MR images at the 24th week of pregnancy show a placenta previa (P), markedly heterogeneous, with multiple intraplacental dark bands (curved arrows, b) and hematic rests, hyperintense on T1-W imaging (c). Note prominent anomalous uterine contour with uterine "bulging" and absence of clear identification of the myometrium between the white arrows in a and d. The patient developed acute severe vaginal bleeding and abdominal pain 24 h after MR exam. Emergency surgery discovered uterine rupture at the old cesarean scar level with partial protrusion of the placenta. The fetus died and hysterectomy was required.

Table 2
Increase in the incidence of placental implantation and adhesion disorders related to the number of prior cesarean deliveries (CD). OR: Odds ratio compared with women without prior cesareans).

	Primiparous	After 1 CD	After 2 CD	After 3 CD	> 3 CD
Pl. previa (PP)	0.3–1.2%	0.8–1.5% OR 1.2–1.9	1.1–2.0% OR: 1.9–2.0	2.8%	
Pl. accreta (PA)	0.04–0.2%	0.3–0.6% OR:1.3–2.16	0.31% OR: 8.6–29.8	0.57%	2.13–6.8%
PA in patients with PP	3–4%	11–14%	23–40%	35–61%	50–67%

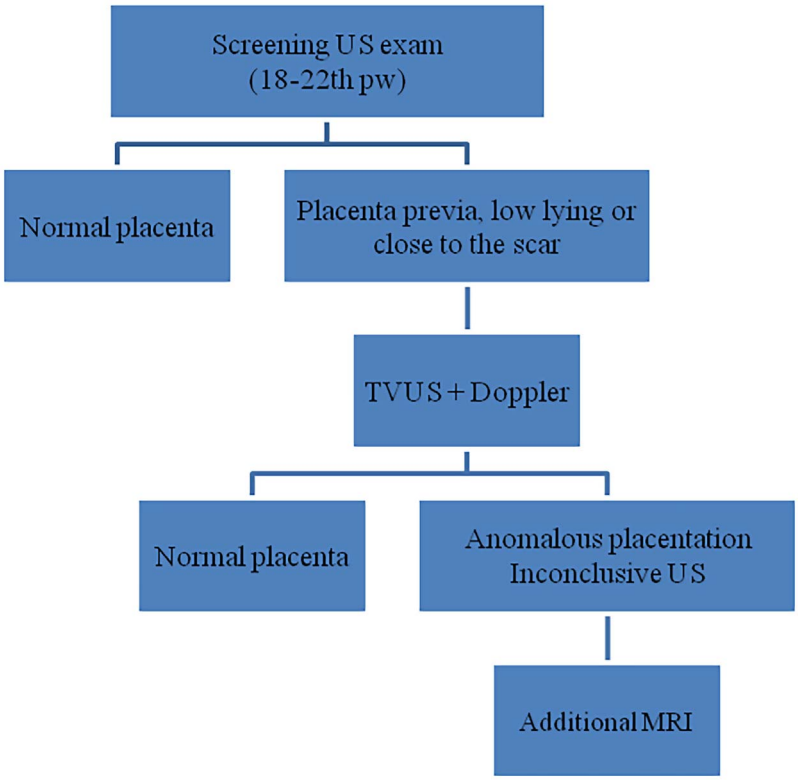

Fig. 13. Proposed algorithm for the appropriate use of imaging methods in pregnant patients with previous cesarean delivery and/or hysterotomy.

Suggestive findings include heterogeneity and increased vascularity of the placenta, abnormal uterine bulging – disruption of the normal uterine inverted pear-shaped form – disruption of the normal zonal anatomy of the cervix and focal interruption of the normal inner low-signal intensity myometrial layer subjacent to the placenta. Randomly distributed dark intraplacental bands with different thicknesses extending from the placenta-myometrium interface are often observed on T2-W images,. Combined presence of these signs could help inexperienced radiologists to establish diagnosis. The "golden combination" suggesting pathology would include PP, a posterior inserted

placenta, a focally interrupted myometrial border and the detection of dark intraplacental bands on T2-W MR images [53,54]. In placenta percreta, MRI can be especially useful in detecting invasion of the parametriums, the bladder and/or the rectum. Retraction or "tenting" of the bladder dome is observed in case of infiltration [50].

In case of confirmed or highly suspected diagnosis, the insertion of angioplastic balloons in the iliac arteries prior to delivery can help control the hemorrhage [55]. Other conservative therapies include segmental myometrial resection or catheter directed uterine arterial embolization when leaving the placenta "in situ". However, infections and secondary complications are often observed and increase the risk of delayed hysterectomy.

3. Coexistence of PP and placental invasion

The risk for placental infiltration is especially high in patients with a prior cesarean delivery that also have PP (Figs. 11 and 12) and increases with the number of previously performed cesareans [48,56]. Table 2 compares the risk for isolated and combined PP and accreta related to the number of prior cesarean deliveries and after an identical number of vaginal deliveries. A deficient decidua basalis at the scar level and a poorly developed decidua at the anterior distal uterus could be at the origin of placental infiltration in low-lying or close to a uterine scar inserted placenta.

4. Management schema in patients with previous cesarean deliveries.-

In pregnant patients with prior uterine scar, screening US should carefully evaluate the position of the placenta. In case of PP, low lying or implanted close to a prior uterine scar, TVUS with color Doppler exam is mandatory to exclude placental infiltration. If TVUS is positive, suspect or equivocal, indication for additional MRI should be seriously considered [57] (Fig. 13). Unfortunately, this schema is only accessible for developed countries.

5. Conclusion

Complications related to uterine scars after cesarean delivery or hysterotomy are now more often detected than ever before, mainly because of the increasing cesarean delivery rates worldwide. In pregnant patients, some of these complications are associated with a high risk of severe perinatal hemorrhages. Early diagnosis is than crucial to identify the risks, guide the management and adequately prepare delivery. TVUS is the main imaging method for diagnosis, but MRI is increasingly used for selected cases.

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